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ABSTRACT

A literature review was conducted to identify factors in recent brain research related to the needs of elementary school students and to provide a comprehensive list of strategies from which teachers may choose to improve the "brain compatibility" of their classrooms. Annotations of 65 articles are provided. Articles are arranged topically in the following 10 categories: hemispheric specialization and split-brain theory, the relationship of hemispheric specialization to education, brain growth periodization theory, triune brain theory, learning style theories, sex differences in information processing, cultural differences in cognitive style, curriculum implications, implications for classroom structure, and teaching strategies. Emphasis is given to learning style theories having constructs related to teaching in elementary school classrooms, to the split-brain concept, and to teaching strategies for "right-brain" activities. Also provided in the document are a very brief overview of theory, a glossary of terms, a summary of findings, a discussion of conclusions, and a statement of recommendations for teachers. An appendix lists activities in several curriculum areas and indicates their appropriateness for seven types of learning styles. Also appended are a brief list of sources of additional information; a chart coordinating teaching models, learning modes and styles, and related theories; and lists of left, right, and integrated brain-dominance characteristics. (RH)

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HEMISPHERIC SPECIALIZATION AND LEARNING STYLE THEORY: SOME CONSIDERATIONS FOR THE ELEMENTARY TEACHER

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INTRODUCTION

Research into the processing mechanisms of the human brain began in the mid-19th century with the work of Marc and Gustav Dax and Paul Broca (Springer and Deutsch, 27). A century later, Joseph Bogen and Philip Vogel pioneered a new era in brain research with experiments using "split-brain patients," whose brains had been split by a surgical procedure called a commisurotomy. In a commisurotomy, the corpus callosum (which connects the two hemispheres of the brain) is severed (Springer and Deutsch, 28). At first, the split-brain patients appeared normal, but later observations showed that they were incapable of performing certain functions (Sperry, 211). Split-brain studies conducted by Bogen, Vogel, and Sperry identified two separate and distinct processing modes within the brain (Springer and Deutsch, 44). This view may be called the split-brain or hemispheric specialization theory.

Two other theories relating to the information-processing aspects of the brain came from the work of Paul MacLean and Herman Epstein. MacLean's concept of the "triune brain" was based on the evolutionary development of the brain from reptiles to mammals to humans (MacLean, 309). Since the three parts of the triune brain were arranged from the brainstem to the frontal lobes, MacLean's theory and the split-brain theory need not be mutually-exclusive (Bogen, 1975, 26).
Similarly, since he did not deal with parts of the brain but with the whole, Epstein's Brain Growth Periodization Theory can exist concurrently with the other two. Epstein found that the brain developed in spurts. These spurts coincided roughly with Piaget's developmental stages (Epstein, 343-344).

MacLean also recognized developmental stages in the growth of the brain (MacLean, 340-341).

Learning style theories are as varied as they are numerous. Some were based on information-processing through sensory channels (Barbe and Milone), others on specific perceptual modes and ordering processes (Gregorc, Kolb, Hill, and McCarthy), and still others on preferences for certain elements in the learning environment (Dunn) (Dunn and others, 374-375).

STATEMENT OF THE PROBLEM

The recent issues of many professional journals are full of newly-discovered facts and theories about the processing and organizational systems of the human brain. Elementary classrooms are full of pupils who exhibit many different modes of processing and organization. Classroom teachers, who are responsible for day-to-day planning for these pupils, often have little or no knowledge about the functioning of the brain. This information gap may have created a system in which many pupils have a minimal chance for school success.

PURPOSE OF THE STUDY

The purpose of the study was to identify factors in recent brain research which relate specifically to the needs of elementary pupils and to provide a comprehensive list of strategies from which teachers may choose to improve the "brain compatibility" (Hart, 306) of their classrooms.

ORGANIZATION OF THE STUDY

A basic overview of some prominent theories concerning current brain and learning style research was included in the introduction. The

remainder of the study will review some of the details of the various theories and briefly note some controversies in the research concerning sex and cultural differences.

The annotations are arranged by subject. Any annotation that logically fits into more than one category was usually placed under the subject heading that fit the majority of its content. However, if a detail in the annotation contained information that was unique to this study, it was placed under the subject of that detail.

The subject headings Curriculum Implications, Implications for Classroom Structure, and Teaching Strategies will not be reviewed in the summary. Instead, they will be presented generally as recommendations and specifically in the appendices. The purpose for using this format is to provide a concise, easy-to-use reference from which teachers may choose strategies which fit their individual needs.

LIMITATIONS OF THE STUDY

Due to the large number of learning style theories, only those with constructs that related to elementary teaching were considered. Similarly, the split-brain concept was given more thorough treatment than the other two theories because the classroom teacher has little control over the kinds of major changes suggested by Epstein and MacLean.

This study was approached from the point of view of a classroom teacher, not a neuroscientist. Therefore, the underlying structure of the paper is based on practicality (usefulness in the classroom) and not on theoretical issues.

Based on the assumption that left-brain activities abound in traditional textbooks, only right-brain activities were provided in the "teaching strategies" section of the paper.

GLOSSARY

abstract random learner -- one who uses an abstract thinking style and a random ordering system (Gregorc and Ward, 21).

abstract sequential learner -- one who uses an abstract thinking style and a sequential ordering system (Gregorc and Ward, 21).

alpha waves -- indicators (on an electroencephalograph) which show which hemisphere of the brain is working (the one without the majority of alpha waves over it).

auditory mode -- mode in which auditory stimuli are processed most efficiently (Barbe and Milone, 45).

axon -- "the core of a nerve fiber that generally conducts impulses away from the nerve cell" (American Heritage Dictionary, 146).

bidirectional -- pattern of eye movement indicating no preference for either right- or -left brain processing (Gur, Gur, and Marshalek, 151).

bilateral representation (bi-lateralization) -- showing no specialization for either right- or -left brain processing; whole-brained (Witelson, 425).

brainstem -- "the part of the brain consisting of the medulla oblongata, pons, and mesencephalon and connecting the spinal cord to the forebrain and cerebrum" (American Heritage Dictionary, 203).

chimeric stimuli -- pictures created by mismatching the halves of two pictures of the same object (e.g. half face of man with other half of a woman) (Sage, 25).

cognitive style -- information-processing style; learning style.

concrete random learner -- one who uses a concrete thinking style and a random ordering system (Gregorc and Ward, 21).

concrete sequential learner -- one who uses a concrete thinking style and a sequential ordering system (Gregorc and Ward, 21).

corpus callosum -- the major neural connection between the two hemispheres of the brain (Springer and Deutsch, 28).

d -- "a measure of the magnitude of differences between two groups, that is, as a measure of effect size" (Hyde, 892).

dendrite -- "a branched part of a nerve cell that transmits impulses toward the cell body" (American Heritage Dictionary, 381).

dimorphism -- "the occurence of two different forms of the same parts" (American Heritage Dictionary, 398).

field dependence -- the opposite of field independence ("the inability...")

field independence -- "the ability... to visually structure or select and use relevant information embedded in a larger interrelated context" (after Witkin in Shade, 226).

forms of representation -- "the devices that humans use to make public conceptions that are privately held" (Eisner, 47).

global learner -- one who learns whole words, sentences, concepts, etc., easier than she/he learns parts (Carbo, 43).

hemispheric dominance -- tendency for one hemisphere (half) of the brain to be dominant for most tasks; used for: cerebral dominance (various sources).

hemisphericity -- term used by Torrance for hemispheric specialization (Torrance, 29).

hemispheric specialization -- tendency for one hemisphere of the brain to be specialized for certain tasks; used for: lateralization, cerebral lateralization, hemisphericity; narrower terms: right-brained, left-brained (Sperry and others).

holistic -- "concerned with wholes rather than analysis or dissection into parts" (American Heritage Dictionary, 617).

integrated processing -- see "whole-brained".

kinesthetic mode -- mode in which kinesthetic (sensed by the muscles) stimuli are processed most efficiently (Barbe and Milone, 45).

learning style -- "...distinctive behaviors which serve as indicators of how a person learns from and adapts to his [sic] environment" (Gregorc, 234).

left mover -- person showing a pattern of eye movement which may indicate right-brain dominance (Gur, Gur, and Marshalek, 151).

meta-analysis -- "a technique for analyzing a body of research on a particular topic by statistical analysis of the analyses of the individual studies (Hyde, 892).

modal shift -- shift in brain processing; can be from right to left or left to right.

modes of treatment -- methods of conveying meaning of conceptualized ideas to others; the "mimetic mode" conveys through imitation, the "expressive" through an analogic mode, and the "conventional" through symbols that have come to have certain meanings within a culture (Eisner 56, 60, 61).

myelin sheath -- the fatty insulation around the axons (Epstein, 343).

neuroscience -- the various sciences related to the study of the nervous system, including neuropsychology, neurophysiology, and neurology (Wittrock, 12).

pathology -- "the anatomic or functional manifestations of disease" (American Heritage Dictionary, 910).

right mover -- person showing a pattern of eye movement which may indicate left-brain dominance (Gur, Gur, and Marshalek, 151).

scatting -- "improvised singing using meaningless syllables" (Wharton-Boyd, 47).

splenium -- "the caudal or posterior portion of the corpus callosum" (de Lacoste-Utamsing and Holloway, 1431).

tactile mode -- term used to denote learners who need to use their hands when learning (as opposed to whole-body movement for kinesthetic learners) (Dunn, Jan., 1983, 26).

visual-constructional -- requiring the use of the visual mode to perform a task such as drawing a three-dimensional cube (Gazzaniga, 28).

visualization -- the formation of a mental image (American Heritage Dictionary, 1352).

visual mode -- mode in which visual stimuli are processed most efficiently (Barbe and Milone, 45).

w^2 -- a measure of effect size which is used to discover the "proportion of the total variance in the population that is accounted for" by a certain variable (Hyde, 893).

Z-lens -- apparatus created by Eran Zaidel for use in split-brain experiments; the Z-lens allows subjects to observe visual stimuli for as long as they wish while using only one hemisphere to process the information (Sage, 28).

ANNOTATIONS

HEMISPHERIC SPECIALIZATION AND SPLIT-BRAIN THEORY

Sperry, Roger W., "Lateral Specialization of Cerebral Function in the Surgically Separated Hemispheres," in The Psychophysiology of Thinking, pp. 209-222, edited by F.J. McGuigan and R.A. Schoonover, Academic Press, New York, 1973.

Sperry described the specialization of functions in the two hemispheres, using information from early works by Broca and Dax (1800's), his (Sperry's) own work, and that of Bogen and Vogel (1960's to present). At first, split brain patients appeared normal, but later study proved that certain functions were lacking. Review of the many studies proved that each hemisphere has its own method of processing, and these processing methods combine to form more complete pictures in the brain than could be formed by one hemisphere alone.

Bogen, Joseph E., "The Other Side of the Brain: An Appositional Mind," in The Nature of Human Consciousness, edited by Robert E. Ornstein, W.H. Freeman and Co., pp. 101-125, San Francisco, 1973.

Bogen cited research from 1864 to 1969 (including his own) as proof that two distinct modes of processing exist in the brain, and that it is possible to function with only one hemisphere intact. Bogen called these two modes "propositional" and "appositional" to avoid any value judgements about which hemisphere is superior. When both hemispheres work together, the capacity for two minds exists. Bogen noted that research into the right (appositional) hemisphere's functioning has been difficult because speech is located in the propositional hemisphere. He suggested that further right brain study is needed.

Gazzaniga, Michael S., "The Split Brain in Man," Scientific American, 217:24-29, August, 1967.

Michael Gazzaniga and Roger Sperry studied split-brain patients at Cal Tech from 1961 to 1967. They focused their research on how the hemispheric separation affected mental capacities. They limited input to one hemisphere by presenting visual information to only one visual field. They found that the left brain was superior to the right in verbal language tasks, but that linguistic capabilities in the right hemisphere varied among individuals. Also, the right brain was capable of responding non-verbally, and it excelled in tasks involving visual construction. Gazzaniga concluded that each hemisphere processed information in its own way and, in normal subjects, shared that information with the other hemisphere.

Sage, Wayne, "The Split Brain Lab," Human Behavior, 5:25-28, June, 1976.

Sage described two techniques used to study lateralized functions in split-brain patients. "Chimeric stimuli" were used by Jerre Levy and her colleagues to test the silent right brain's recognition of pictures. Eran Zaidel developed the "Z-lens", which gives subjects the opportunity to "see" with only one hemisphere for extended periods. Sage concluded by stating that educators should be aware of right/left brain differences.

Brandwein, Paul, and Ornstein, Robert, "The Duality of the Mind," Instructor, 86:56-58, January, 1977.

In these excerpts from a symposium on the human brain, Brandwein and Ornstein discussed the physiological and psychological differences in the hemispheres. Ornstein stated that the evidence supports the idea of the brain as two separate systems. In his own study using an electroencephalogram to monitor the alpha waves of normal subjects. Ornstein found that the left hemisphere controls "sequential" functions, while the right controls "simultaneous" activities. Brandwein offered some strategies for using the whole brain. Among these were that teachers should sometimes use holistic modes of teaching; schools should seek alternative curriculum models; intuition should be considered as a partner to intellect; and children should be given more time to respond to teachers' questions.

Buck, Craig, "Knowing the Left from the Right," Human Behavior 5:29-35, June, 1976.

Buck reviewed some of the early studies of hemispheric differences. He stated that the real question to be answered is not what each hemisphere does, but why it does it. He provided numerous examples of hemispheric differences in the areas of music, gesturing during speech, alcohol and marijuana use and their effects on lateralization, sex differences, animal studies, humor (differences between sexes for reaction to humor), the "competition theory" of brain evolution (developed by Jerre Levy), development of lateralization, and Braille reading.

RELATIONSHIP OF HEMISPHERIC SPECIALIZATION TO EDUCATION

Watson, E. Selman, and Engle, Randall W., "Is It Lateralization, Processing Strategies, or Both That Distinguishes Good and Poor Readers?" Journal of Experimental Child Psychology 34:1-19, August, 1982.

The purpose of this study was to determine whether recall performance (immediate and delayed) was affected by varying the ear to which information was presented. Good and poor readers were tested for recall of words, digits, and consonant/vowel (CV_2 and CV_3) combinations. Results for immediate recall showed significant, though not very large, tendency for a right ear advantage (especially for normal readers.) Results for delayed recall showed very large differences between normal and poor readers. However, these differences were not specific to either ear. Watson and Engle concluded that the ear asymmetry effect is probably greater for normal than for poor readers, and that poor readers may have a memory deficit which is more responsible for results than ear asymmetry alone.

Reynolds, Cecil R.; Kaltsounis, Bill; and Torrance, E. Paul, "A Children's Form of Your Style of Learning and Thinking: Preliminary Norms and Technical Data," The Gifted Child Quarterly 23:757-767, Winter, 1979.

The instrument, "Your Style of Learning and Thinking" (SOLAT) was based on hemispheric specialization research. It was designed to measure hemisphericity. The children's forms A and B (reproduced in this article) were developed by lowering the reading level, to about fourth grade, for items from the adult SOLAT. Reynolds, Torrance, and Kaltsounis reminded potential users of the instrument that it is still in a research edition form and should be interpreted accordingly. Scoring for the children's forms was the same as for the adult SOLAT. Preliminary reliability data showed that the Integrated scale was most reliable for males and least reliable for females. The Right and Left scales yielded good reliability for females and mixed results for males. Sex differences were conceivably due to small subsamples. Normative data were included, but users were cautioned to interpret it carefully, as validity data was not yet available.

Torrance, E. Paul, "Hemisphericity and Creative Functioning," Journal of Research and Development in Education 15:29-37, Spring, 1982.

Torrance compared various instruments used to assess creative style and ability to "Your Style of Learning and Thinking" (SOLAT), an instrument used to assess hemisphericity. The subjects for this study were graduate students who were all tested using the SOLAT and some or all of the other measures. The results showed that measures of creative style were generally positively related to right and negatively related to left hemispheric style. No significant correlation was shown for the integrative style or for the measures of creative ability. Torrance noted some studies that used children as subjects, but he stated that most research of this kind had not proved conclusive.

Rice, Dale R., and Languis, Marlin L., "What is for Real in Communication: Your Right-Left Brain Decides," Reading Improvement 16:50-54, Spring, 1979.

Rice and Languis used basic information from hemispheric specialization research to conclude that the authenticity of verbal communication was derived from the right brain. Their conclusions were based on the fact that the right brain excels in non-verbal functions and is more attuned to non-verbal details, such as facial expression. Rice and Languis found that, when verbal and non-verbal communication cues agreed (e.g. words of praise given by a smiling teacher), no special effort needed to be made in decoding the message. However, if the verbal and non-verbal cues conflicted, the right brain decoded the non-verbal cues to decide the true message. Rice and Languis cautioned teachers to use non-verbal cueing that matched their verbal cues.

Shook, Ronald, The Two Brains and the Education Process, Educational Resources Information Center, ED 218 360, National Association for Asian and Pacific Education, March, 1981, 26 pp.

Shook attempted to dispel some popular assumptions about brain function. He stated that many researchers assume that the left brain is rational and the right intuitive. He refuted this view by noting that measures for assessing hemispheric dominance may be inadequate. Shook suggested that the hemispheres do interact, although he stated that researchers assumed that they don't. [Most recent research states that the hemispheres are separate entities and can work alone, but that they work best together.] Finally, Shook stated that information about hemispheric specialization is not useful for educators since good teachers have been teaching to both brains all along. [While that may be true, studies show that most teachers tend to use mostly left-brained methods.]

Springer, Sally P., and Deutsch, Georg, Left Brain/Right Brain, W.H. Freeman and Co., San Francisco, 1981, 243 pp.

Springer and Deutsch dealt with such topics as pioneers in the field (Dax, Broca, Wernicke, Myers, Sperry, Vogel, and Bogen), studies based on pathologies and injuries, split-brain surgery, drug injections, and electrical stimulation of various areas of the brain. The authors concluded that: 1) Handedness doesn't provide much information. 2) The brain adapts to injuries and compensates for its own weaknesses. 3) There are some problems with the clinical data concerning what factors cause the brain to switch its pattern of functioning. 4) Language seems to be the major difference between the hemispheres. 5) Individual variation among subjects is more important than differences found between groups. Springer and Deutsch pointed to differences in the theories relating to when lateralization first begins in humans. They concluded by stating that further research, as well as cooperation between physiology and psychology, will be necessary to solve the mysteries of lateralization.

BRAIN GROWTH PERIODIZATION THEORY

Epstein, Herman, T., "Growth Spurts During Brain Development: Implications for Educational Policy and Practice," in Education and the Brain, pp. 343-370, edited by Jeanne S. Chall and Allan F. Mirsky, The Seventy-Seventh Yearbook of the National Society for the Study of Education, pt. 2, University of Chicago Press, Chicago, 1978.

It is known from biology that the formation of brain cells ceases at about the end of the second year of life. However, brain weight increases about 35% after that time. Therefore, growth must be within the brain cells (probably through the extension and branching of axons and dendrites or the laying of the myelin sheath.) According to Epstein, either of these growth processes would result in an increase in the brain's complexity. Epstein discovered that brain growth occurs in spurts, followed by plateaus during which growth is limited. He found that for 85% of children, these brain growth spurts occur at specific stages: 3-10 months, 2-4, 6-8, 10-12 or 13, and 14-16 or 17 years. Head circumference studies showed evidence of growth at the same stages. Epstein compared his brain growth stages to Piaget's stages of intellectual development. Recent work by Arlin (1975) evidenced the possibility of a fifth stage. Combining the stages of Piaget and Arlin, Epstein found a perfect match to his brain growth stages. He suggested that schooling should focus on presentation of novel intellectual material during spurts, memorization and review activities during plateaus, and evaluation based on knowledge of both.

TRIUNE BRAIN THEORY

MacLean, Paul D., "A Mind of Three Minds: Educating the Triune Brain," in Education and the Brain, pp. 308-342, edited by Jeanne S. Chall and Allan F. Mirsky, The Seventy-Seventh Yearbook of the National Society for the Study of Education, pt. 2, University of Chicago Press, Chicago, 1978.

The concept of the "triune brain" originated with Paul D. MacLean. He described the brain's three parts as follows: the r-complex, or reptilian brain, which controls "primal" behavior (routines and rituals in humans); the limbic system, or paleomammalian brain, which controls self-preservation, procreation, and emotions; and the neocortex, also called the neomammalian or "new brain," which controls rational behavior. MacLean stated that only the neocortex possesses the ability for syntactical speech, although the R-complex and limbic system are capable of nonverbal responses. MacLean mentioned that the tip of the neocortex, known as the prefrontal cortex, seems to possess special functions for empathy and identification. MacLean concluded that all three parts of the brain are involved in learning, but he postulated that certain types of learning may need to take place at specific times during development.

LEARNING STYLE THEORIES

Dunn, Rita, and others, "Learning Style Researchers Define Differences Differently," Educational Leadership 38:372-375, February, 1981.

Dunn and her colleagues reviewed the learning style theories of Canfield and Lafferty; Dunn, Dunn, and Price; Gregorc; Hill; Hunt; Kolb; Ramirez and Castañeda; and Schmeck. Definitions of learning style, assessment instruments, and applications of each theory were compared. Many similarities, as well as many differences, emerged from the findings. No value judgements were made concerning which theory was most correct. Dunn (et. al.) expressed hope that the diversity of information would serve to provide a more complete approach to programs based on learning style research.

Dunn, Rita, "You've Got Style," Early Years 13:25-31, 58-59, January, 1983.

This article was the second in a series based on Dunn's "Productivity Environment Preference Survey" (PEPS), which had appeared in the first article. The series allowed an adult to take the survey, send it in and receive computer-scored results, read them, and plan around them. The PEPS provided information on learning preferences based on the following twenty-one elements: noise level, light, temperature, design, motivation, persistence, responsibility, structure, learning alone, peer orientation, presence of authority figures, learning in several ways, auditory, visual, tactile, kinesthetic, requiring intake (smoking or food), preference for evening-morning, preference for late morning, preference for late afternoon, needing mobility. Dunn's research showed that most people are affected by only a few of the elements and the effect can be positive (they need that element to do their best work) or negative (they can't produce quality work under those conditions). Other elements may make no difference. Dunn provided directions for reading a PEPS Individual Profile to decide which elements are necessary and which are counterproductive to learning.

Dunn, Rita, "Now That You Know Your Learning Style," Early Years 13:49-54, February, 1983.

In this article, third in a series [see above] Dunn suggested some ways to implement a learning program based on a personal profile of learning style preferences. She stated that a room, a corner of a hallway, or even a closet could become the perfect place to learn free from interruption by the body's demands. Dunn provided some examples of simple additions to the environment, like earphones for those who need quiet. She described certain elements which often group together (e.g. high motivation and low persistence - a combination which may result in hundreds of unfinished products!) The PEPS is not recommended for use with children, but another instrument (the Learning Style Inventory) has been used in numerous studies with children. Dunn revealed some of the findings of these studies, including that gifted children often score high on the elements of motivation, persistence, learning alone, and a combination of the sensory modalities. Researchers found that underachievers' learning preferences often don't match the environment in their classrooms.

Dunn, Rita, "Can Students Identify Their Own Learning Styles?" Educational Leadership 40:60-62, February, 1983.

After testing 175,000 pupils in grades 3-12, Dunn concluded that most children can identify their own learning styles. [Dunn's definition of learning style was based more on environmental factors than cognitive processes.] Students only identified elements that were negatively or positively important to them. However, that information was enough to provide for optimum learning conditions. Dunn cited studies at the college level (Farr, 1971 and Domino, 1970), the high school level (Cafferty, 1980; Copenhaver, 1979; Douglass, 1979; Lynch, 1981; and Shea, 1983), and the elementary level (Pizzo, 1981 and Krimsky, 1982). These studies all reported that pupils showed significantly higher scores in academic achievement and attitude when their learning style preferences were matched to their teachers' styles. [This article included a good visual representation of the various factors that can be considered in determining an individual's learning style.]

Barbe, Walter, and Milone, Michael N., "Modality," Instructor 89:44-47, January, 1980.

Barbe and Milone defined modality as "the sensory channel through which information is processed most efficiently" (p. 45), adding that the most important modalities are visual, auditory, and kinesthetic. They stated that modality-based instruction is not new, citing work by Maria Montessori and Grace Fernald. Barbe and Milone listed some instruments which can be used to assess a pupil's modality strength. They stated that research has shown that among elementary-aged children, about 30% are visual, 25% are auditory, and 15% are kinesthetic. These strengths tend to become more mixed as a child ages. Barbe and Milone stated that pupils with mixed modality strengths have an advantage in the classroom. The article concluded with suggestions for specific teaching strategies.

Gregorc, Anthony F., and Ward, Helen B., "A New Definition for Individual," NASSP Bulletin 60-61:20-26, February, 1977.

Gregorc and Ward considered the concept of duality and its relationship to education. Based on this concept, they conducted a research study to find out how dualities manifest themselves in learning and how to successfully teach to create a balance. Gregorc and Ward found two sets of dualities based around abstract/concrete thinking and sequential/random ordering. These dualities were formed into four learning preference patterns: abstract sequential, abstract random, concrete sequential, and concrete random. All subjects interviewed used all four modes, but at least 90% showed a preference for one or two. Gregorc and Ward offered brief descriptions of each type of learner. They suggested two alternative approaches to teaching that allow for differences in learning preferences. Both approaches stressed the need to teach to pupil's strengths and to help them expand.

McCarthy, Bernice, The 4-MAT System, EXCEL, Inc., Publishers, Oak Brook, Ill., 1980, 220 pp. (Available through EXCEL, Inc.)

McCarthy correlated the basic learning style theories of Kolb (1974), Lotas, Jung (1976), Fischer (1979), Gregorc (1979), Wetzig, and Merrill (1976). She placed each of these theories into a similar form, showing four distinct learning styles, and the resulting patterns were then placed along the continuum of Piaget's model. McCarthy's own model, which also allowed for hemispheric preference, characterized the four types of learners as to their perception of reality, preferred learning modes, and needs as students. Type One Learners need to be motivated and involved, and they learn best by listening and sharing ideas. Type Two Learners need facts and details, and they learn by processing ideas through thinking. Type Three Learners need to know how things work, and they learn by doing and by testing their own ideas. Type Four Learners need to know what can be done with things, and they learn by trial and error and self-discovery. There are right/left/whole-brained learners in each of the four groups. McCarthy concluded her book with sample lesson plans for teaching to all four styles, thereby allowing for success in the preferred mode and "stretching" in the other modes.

Gregorc, Anthony F., "Learning/Teaching Styles: Potent Forces Behind Them," Educational Leadership 36:234-236, January, 1979.

In this editorial, Gregorc noted that teacher-selected teaching styles place adaptation demands on pupils. Success may depend on a pupil's ability to adapt to the teacher's style. Gregorc stated that an inability to adapt may lead to discipline problems. He warned against unquestioned reliance on learning assessment instruments because, like all instruments, they tend to exclude certain possibilities, and, because pupils may report the mode they are used to using rather than the one they prefer, Gregorc concluded with a reminder that teacher attitudes affect any form of assessment. He suggested that careful consideration be made before any changes are implemented on the basis of learning style assessment.

Davidman, Leonard, "Learning Style: The Myth, The Panacea, The Wisdom," Phi Delta Kappan 62:641-645, May, 1981.

Davidman described learning-style-based education as a bandwagon which should be jumped onto with caution. He examined the work of Rita and Kenneth Dunn with Gary Price. He compared their work to that of David Hunt. Davidman expressed concern that neither Hunt nor the Dunn/Price group demonstrated knowledge concerning the extent to which learning style can be modified. In comparing the two theories, Davidman found that Hunt's assessment techniques were more informal and that his recommendations were based on the idea that learners should adapt to schools as well as vice versa. The Dunn/Price group provided detailed plans for the adaptation of schools, and their assessment instrument was a computer-scored-self-report inventory. Davidman questioned the ability of a child or a computer to decide the proper balance needed for schools to serve society and the individual. Davidman concluded that teacher observation, open dialogue with pupils, and standardized assessment should be used to create "a responsible form of personalized education" (p. 645).

Kuchinskas, Gloria, "Whose Cognitive Style Makes the Difference?" Educational Leadership 36:269-271, January, 1979.

Kuchinskas used a cognitive mapping instrument developed by J.E. Hill (1969), informal interviews and observations, and reviews of records to study cognitive styles in thirteen third- and fourth-grade classrooms. She found that the teacher's cognitive style had a stronger effect on the classroom than any other variable. Kuchinskas cited other research to support this view. She suggested that teachers should be aware of the way in which their cognitive style affects their classrooms.

SEX DIFFERENCES IN INFORMATION PROCESSING

Maccoby, Eleanor Emmons, and Jacklin, Carol Nagy, The Psychology of Sex Differences, Stanford University Press, Stanford, Calif, 1974, 634 pp.

Maccoby and Jacklin discussed eight unfounded and four well-established sex differences. Of the latter, all but one related directly to education. Girls showed superior ability on verbal tasks, while boys excelled in visual-spatial and math ability at certain ages. Maccoby and Jacklin cited possible problems with their data, including distortion due to stereotyping or sex bias, age-specific emergence of traits, situation-specific differences, lack of reliable data based on age comparisons, and research settings that don't match reality. Reasons given for sex differences included genetic factors, shaping by parents and others, and spontaneous learning through imitation. Maccoby and Jacklin warned against teaching to sex differences, suggesting instead that pupils' weaknesses be strengthened.

Keenan, Donna, and Smith, Michael, "Sex Discrimination and Cerebral Bias: Implications for the Reading Curriculum," Reading Improvement 20:50-53, Spring, 1983.

Keenan and Smith gave numerous examples of studies showing that female subjects demonstrate superiority in verbal skills, while male subjects are better at visual and spatial skills. Citing the work of Sperry and others, Keenan and Smith asserted that the reason for these differences may be sex differences in hemispheric specialization. They maintained that, whatever the reason, much school time is spent on the "basics" (primarily taught using left-brain methods), and that "right-brain" subjects, such as art and music, are often the first to be cut out of curriculum because they are considered unnecessary in academic terms. Keenan and Smith expressed a concern that the current trend in education (to cut out the "frills") penalizes male students and gives female students an advantage. They hoped that researchers would pursue further study into this subject.

Witelson, Sandra F., "Sex and the Single Hemisphere," Science 193:425-427, July 30, 1976.

Using a sample of 200 boys and girls, aged six to thirteen, Witelson studied right-hemispheric specialization for spatial processing. She found that boys showed right-hemispheric spatial processing by age six, whereas girls showed bilateral representation to age thirteen. This dimorphism covered an extended period of development. Therefore, Witelson postulated that educators should consider these differences when planning strategies for teaching reading.

de Lacoste-Utamsing, Christine, and Holloway, Ralph L., "Sexual Dimorphism in the Human Corpus Callosum," Science 216:1431-1432, June 25, 1982.

Holloway and de Lacoste-Utamsing studied the shape of the corpus callosum in nine female and five male brains obtained upon autopsy. They found no sex differences in absolute length. However, they found that the splenium (the posterior portion) in females showed a larger surface area than in males. The splenium has been shown to be important in the processing of visual information. Also, since the corpus callosum is the major connection between the hemispheres, the larger splenium in females may help to explain why they tend to show less lateralized brain function than males. [It should be noted that the sample population of this study was rather small. Further supporting data are needed.]

Hyde, Janet Shibley, "How Large are Cognitive Gender Differences?" American Psychologist 36:892-901, August, 1981.

Hyde's research focused on the "well-established" findings of Maccoby and Jacklin in their 1974 study. Hyde reanalyzed the factors of female verbal superiority and male visual-spatial and math superiority, using a meta-analysis technique. She computed two statistical measures ("w^2" and "d") of the magnitude of gender differences in the total population. Results showed that gender differences for the three variables studied were all small (accounting for no more than 1%-5% of total population variance). Hyde warned that use of the Maccoby/Jacklin findings could lead to a perpetuation of sex discrimination in career counseling (based on the "well-established" facts). She suggested that researchers continue to study sex differences using careful sampling techniques and sufficient information reporting.

CULTURAL DIFFERENCES IN COGNITIVE STYLE

Shade, Barbara J., "Afro-American Cognitive Style: A Variable in School Success?" Review of Educational Research 52:219-244, Summer, 1982.

Shade suggested that the discrepancy between the capabilities of Afro-American pupils and their performance on standardized tests resulted from certain factors relating to cognitive style. She described the following as characteristics of an Afro-American style: cautious world view, holistic environmental view, preference for intuitive reasoning, reliance on non-verbal cues, orientation to people (as opposed to objects), and a visual/field dependent perceptual style. Shade characterized schools as valuing a sequential, analytic, object-oriented, verbal and field-independent cognitive style. Therefore, Shade concluded that poor performance by Afro-American pupils on standardized tests resulted from the difference between their cognitive style and that preferred by schools. Since Afro-American cognitive style seems unlikely to change, Shade suggested that schools adapt teaching/testing methods to fit a variety of cognitive styles.

Slaughter, Charles H., "Cognitive Style: Some Implications for Curriculum and Instructional Practices Among Negro Children," Journal of Negro Education 38:105-111, Spring, 1969.

Slaughter explained some aspects of cognitive style which are specific to culturally-disadvantaged youth (Negro pupils in particular). Barclay and Cusamano (1967) studied boys without fathers. They found that Negro boys tended to respond like boys without fathers (showing a field-dependent style) regardless of their home situation. These results suggested a need for teachers to provide Negro pupils and culturally-disadvantaged pupils with specific tasks, organization, and reinforcement. A teaching model that was suggested for use with Negro pupils was Inquiry Training, a technique which resembles Twenty Questions. Slaughter concluded that special classroom techniques are no replacement for an open society. However, since social problems won't disappear overnight, changes in the educational picture are needed now.

Ramirez III, Manuel and Price-Williams, Douglass R., "Cognitive Styles of Children of Three Ethnic Groups in the United States, Journal of Cross-Cultural Psychology 5:212-219, June 1974.

Ramirez and Price-Williams studied 180 fourth-grade children from Mexican-American, Black, and Anglo-American backgrounds. Sample groups were equally-proportioned with regard to sex and socio-economic status. Most of the Black and Mexican-American subjects were bilingual, they identified with cultural values showing respect for adults, family, and religious authority, and they had close ties to the extended family. Most Anglo-American subjects did not identify with their ethnic heritage, they valued independence from family and convention, and none were bilingual. The Portable Rod and Frame Test (Oltman, 1968) was used to determine the field-dependent/independent styles of the subjects. Findings showed Black and Mexican-American subjects to be more field-dependent. Ramirez and Price-Williams cited cultural differences as the cause of this finding, since socioeconomic status proved to be an insignificant variable. Because classrooms and tests tend to be biased in favor of field independence, a Black/Mexican-American cognitive style favoring field-dependence could affect school performance.

Robeck, Carol P., "A Study of Cognitive Style, Knowledge of Linguistic Concepts, and Reading Achievement of First and Third Grade Children," Reading World 22:98-110, December, 1982.

The purpose of Robeck's study was to investigate the relationship among the variables of cognitive style, linguistic concept understanding, knowledge of word boundaries and reading. Data were collected from 35 first and 31 third grade children. Using the children's Embedded Figures Test and other measures, she found a substantial relationship in the first grade group which appeared weaker by third grade. Results of the study led Robeck to conclude that field dependent pupils had more difficulty in separating individual words from the surrounding field, and that each of the variables tested had more effect on beginning readers. She stated that further data are needed. [The connection between field-dependence and culturally different learners was not considered in this study.]

Cureton, George O., "Using a Black Learning Style," The Reading Teacher 31:751-746, April, 1978.

Some people oppose the idea of a Black learning style because, they contend, it perpetuates the myth of Black inferiority. Instead, they say, Black pupils simply are unmotivated. Cureton agreed that motivation may be a part of the issue, but he maintained that problems related to differences in cognitive style cannot be alleviated simply by motivating Black pupils. He also discounted the notion that any cognitive style is "inferior": each has its own strengths and weaknesses. Cureton found that inner-city children learn best in close interaction with the teacher and when they are orally and physically involved in lessons. He also found that they exhibit poor auditory skills and difficulty in test-taking. He suggested that teachers use listening games and give pupils ample opportunities to practice taking tests (especially in timed situations).

Hollins, Etta Ruth, "Beyond Multicultural Education," Negro Educational Review 33:140-145, July-October, 1982.

Hollins argued for the creation of a multi-cultural theory of learning. She stated that Piaget's theory did not allow for cultural differences in the onset of the various stages. Hollins found that most other learning theories also lacked a multi-cultural or cross-cultural dimension. She stressed that anyone formulating a multicultural learning theory would need to take into account the cultural bias inherent in most related research. Hollins cautioned that multicultural education could not continue without the development of a truly multicultural theory of learning.

CURRICULUM IMPLICATIONS

Price, Gary E., Dunn, Rita; and Sanders, William, "Reading Achievement and Learning Style Characteristics," The Clearing House 54:223-226, January, 1981.

Eighty-five third and sixth grade pupils from three New York City schools were studied, using New York State's Pupil Evaluation Program (PEP) to assess reading ability and Dunn, Dunn, and Price's (1975) Learning Style Inventory (LSI) for learning style assessment. The group's mean reading score of 35.58 was used to divide the subjects into high-and low-ability groups. The statistical analysis was designed to determine which LSI variables discriminated between high and low reading ability. The results of the study showed that high-ability readers preferred dimly-lit, formal atmospheres, were self-motivated, persistent, and responsible, required opportunities for mobility, and did not prefer a kinesthetic learning mode. Price, Dunn, and Sanders suggested that pupils with these characteristics should be exposed to reading earlier than others. Similarly, since low-ability readers showed a kinesthetic preference, that modality should be used to teach them reading.

Shannon, Maureen, and Rice, Dale R., "A Comparison of Hemispheric Preference Between High Ability and Low Ability Elementary Children," Educational Research Quarterly 7:7-15, Fall, 1983.

Shannon and Rice proposed that students in a high ability group would be more likely to use an integrated processing style as measured by "Your Style of Learning and Thinking" -SOLAT (Reynolds, et. al., 1979, Kraft, 1979). Shannon and Rice used the children's form of SOLAT since their sample consisted of seventy elementary pupils. Thirty-seven pupils were labeled as gifted, thirty-three as learning disabled or mentally handicapped (determined by WISC-R IQ scores). Results confirmed that the high ability group showed integrated processing skills, while the low ability group showed a preference for right or left hemispheric responses. Shannon and Rice suggested that schools should provide a balanced curriculum to improve the integrated processing abilities of all pupils.

Bogen, J.E., "Some Educational Aspects of Hemispheric Specialization," UCLA Educator 17:24-32, May, 1975.

Bogen listed numerous authors who have suggested the existence of two parallel "ways of knowing." His own descriptive terms for these "ways" were "appositional" and "prepositional." He characterized hemispheric differences as process-specific (rather than material-specific). He cited MacLean in noting that each hemisphere possesses its own affective apparatus in the limbic system. Bogen warned that school programs stressing the "three R's" tend to ignore half of the brain. He also discounted the use of IQ tests as predictors of life success because the criterion for "success" is poorly defined. Bogen concluded that educators should give equal time to teaching to each hemisphere.

Levy, Jerre, "Research Synthesis on Right and Left Hemispheres: We Think with Both Sides of the Brain," Educational Leadership 40:66-71, January, 1983.

Levy listed and refuted many false assumptions about brain organization. She stated that, even though the right and left hemispheres differ in processing modes, they are not opposites and they work together. Levy noted these facts about the brain: in most right-handers, speech resides in the left hemisphere, however, both hemispheres supply information essential to a deep understanding of language; emotion and humor come mostly from the right hemisphere; both hemispheres are involved in logic, reasoning, and thinking, as well as music and art. Levy suggested that educators engage the emotion of the right brain and expand students' abilities in both right and left processing modes.

Eisner, Elliot W., Cognition and Curriculum: A Basis for Deciding What to Teach, Longman, Inc., New York, 1982, 96 pp.

Eisner proposed some conceptual and practical changes in curriculum, stressing variety in the expression of "forms of representation." He stated that most elementary school curricula stress strict rules for the treatment of forms of representation, thereby restricting pupils and teachers to the idea that everything has one right answer. He suggested that schools expand their curricula to include more material presented in the expressive and mimetic modes. He also expressed his opinion that pupils should be allowed more choice in modes of response (i.e. evaluation techniques should allow for creative responses by pupils). Eisner added one final note that school systems should form partnerships with schools of education to provide a realistic testing ground for new ideas.

Brown, George Isaac; Phillips, Mark; and Shapiro, Stewart, Getting It All Together: Confluent Education (Fastback), Phi Delta Kappa Educational Foundation, Bloomington, Ind., 1976, 34 pp.

Brown and his colleagues outlined a plan for developing personal integration, responsibility, awareness, and responsiveness in pupils by using "confluent" education (a combination of affective and cognitive techniques). Confluent education appeared to utilize many activities which would stimulate right brain function. Brown cited a study in Philadelphia in which confluent education techniques caused an increase in reading comprehension, English, and social studies grades for over half of the experimental group pupils. Brown suggested that a possible reason for this effect was that the pupils became personally involved in their learning. He concluded by stating that personal growth gains shown by the Philadelphia study were as important as the academic gains.

Kane, Nancy, and Kane, Martin, "Comparison of Right and Left Hemisphere Functions," The Gifted Child Quarterly 23:157-167, Spring, 1979.

Kane and Kane's article related the "basics" of hemispheric specialization. Their use of charts to list the various functions of each hemisphere should be of use to teachers. Kand and Kane also offered numerous examples of activities which can be used to stimulate activity in one hemisphere or the other. They offered these general suggestions: teach to both hemispheres, offer students flexible seating choices, be aware of sex differences in verbal and visual/spatial ability, introduce new concepts in both modes, and provide stimulation to remediate deficiencies in the functioning of either hemisphere.

Grady, Michael P., and Luecke, Emily A., Education and the Brain (Fastback), Phi Delta Kappa Educational Foundation, Bloomington, Inc., 1978, 42 pp.

Grady and Luecke noted some basic information about hemispheric preference, but their primary intent was to provide a practical guide for teachers. They stated that special educators have used right-brain techniques in teaching for years, but that other teachers have tended to teach in a more left-brained mode. They suggested that all areas of education would benefit from a more holistic, right-brained approach. Some specific ideas offered by the authors included using more video teaching (a right-brained mode), encouraging pupils to picture ideas before answering, giving them a choice between writing or illustrating, explaining concepts verbally and visually, incorporating music, art, and gym into more linear subjects, and occasionally teaching to only one hemisphere to stimulate growth. The authors stated that, in all areas, teachers should be aware of pupils' preferred learning styles.

Hart, Leslie A., "Three Cheers for Smaller Failures?" Phi Delta Kappan 64:303-307, January, 1983.

Hart questioned the effectiveness of the present educational system. He blamed the failures of schools on repeated attempts to solve the wrong problems. He suggested that schools need to create an education system that is "brain-compatible." He described a "brain-compatible" school as one which requires pupils to actively involve their brains in the learning process. Hart partially blamed pupil failure on the tendency of schools to stress specific right answers and rote memory. He stated that this kind of teaching may actually hinder learning. Hart advised schools to provide huge amounts of random, varied input for pupils to sort out using methods which require active processing and mastery of the material (not a passing grade). Hart concluded that his recommended system would produce excellence in student performance and increased public support for education.

Wittrock, M.C., Editorial, Educational Leadership 30:12-13, 15, October 1981.

In the search for educational implications derived from brain research, Wittrock claimed that researchers must not try to equate education and neuroscience. He recommended that educators seek patterns related to learning, teaching, and paradigms for educational research. Wittrock described learning as a generative process in which the brain of the learner is actively involved and has specific processing skills. He stated that the limbic system and the brainstem are important because of their arousal and attending functions. Because learners remember what they actively construct, Wittrock advised teachers to motivate and assist pupils in the construction of mental images. He maintained that repetition and reinforcement would not keep pupils actively involved. Citing MacLean (1978), Wittrock added that instruction should correspond with brain growth and development and allow for the effects of nutrition and environmental simulation. Wittrock concluded that educational researchers cannot ignore the neuroscience fields in creating paradigms which allow for variation in the information-processing functions of the brain.

Toepfer, Conrad F., Jr., "Curriculum Design and Neuropsychological Development," Journal of Research and Development in Education 15:1-11, Spring, 1982.

The basic premise of this article was that curriculum should be based on learners' needs, as defined by the current brain research. Toepfer cautioned however, that the new information should be carefully studied before any major decisions are made. He suggested that teams of neuroscientists and curriculum experts be formed to work together so as to avoid the bias of either group alone. The major areas that Toepfer discussed are brain growth periodization and cerebral laterization and dominance. He cited work by Piaget and Epstein, as well as others. Epstein's work with brain growth periodization showed that the brain had periods of rapid growth, during which more complex thinking skills could be taught. During "plateau" periods, the brain was not capable of moving to higher thinking skill processes. Growth periods and plateaus could be predicted by the use of various instruments, and these periods seemed to fall within certain age brackets. Toepfer felt that the findings in the areas of brain growth periodization and lateralization should be considered in all curriculum planning.

Cramer, Jerome, "The Latest Research on Brain Growth Might Spark More Learning in your Schools," The American School Board Journal 168:17-20, August, 1981.

Cramer briefly described Herman Epstein's brain growth stages. (For details, see Epstein article, p. 13). Cramer outlined Epstein's recommendations for educators. These included: 1) giving special attention to plateau periods to avoid presenting pupils with material which is beyond their capacity, 2) promoting pupils to higher cognitive skill levels based on their brain growth stage, 3) giving gifted children more material during a growth spurt, but not pushing them into the next stage before they reach it, 4) using an accurate method to determine a child's level of cognitive development (e.g., a test developed by Michael Shayer), and 5) having children memorize songs and poetry during plateau periods. Epstein tried out his theory on a group of eighteen junior high (plateau stage) pupils in New York. He pulled them out of school to work in day care or geriatric facilities twice a week. He witnessed some amazing behavioral changes and improvement in grades. Another study was begun in an entire school district in New York. Results were not available at the time this article was printed.

Dunn, Rita, "Now That You Understand Your Learning Style", Early Years 13:41-45, 62, March, 1983.

To help pupils learn through their learning style preferences, Dunn suggested use of her two children's instruments, the Learning Style Inventory (for grades 3-12), and the Primary Version (for grades K-2). She suggested that teachers explain the concept of learning styles to pupils. After receiving the computer-printed pupil profiles, the teacher should pass them out and discuss them with pupils. Dunn then offered three alternatives: change the classroom environment to fit student needs, modify lessons to fit modality strengths, or provide for pupils who need to work alone, with peers, or with the teacher. She suggested that teachers keep records of pupil progress, and she offered various resources that can be purchased for teachers who want to expand their knowledge of learning styles.

Wellman, Mary M., "Teaching Handwriting: Implications of Neuropsychological Research," Reading Improvement 20:54-57, Spring, 1983.

Wellman presented evidence from neuropsychological research to prove that pupils' natural writing positions should not be altered by teachers. To support this position, Wellman cited research with adults which showed that right-handers who use the straight position and left-handers who use the inverted position exhibit left-brain function for language and right-brain function for spatial tasks. However, right-handers who use the inverted position and left-handers who use the straight position were found to exhibit the opposite pattern for hemispheric specialization (right: language, left: spatial functions). Wellman noted that children's writing positions may change as they get older.

IMPLICATIONS FOR CLASSROOM STRUCTURE

Dunn, Rita, and Dunn, Kenneth, "Redesign Your Classroom," Instructor 87:124-131, October, 1977.

Dunn and Dunn delineated the specific steps involved in designing a classroom based around the learning preference profiles of the pupils who will use it. The steps, in order, are: 1) Involve pupils in the rearrangement process. 2) Locate as many room dividers as possible. 3) Clear the floor of boxes and other materials. 4) Redesign one wall at a time, beginning with a wall which has no windows or board. 5) Redesign the window wall, the chalkboard wall, and the entrance wall. 6) Redesign the center of the room. (The teacher's desk will probably be here.) 7) Test the design to see if it is effective. 8) Show off the new classroom. Each classroom design should reflect the individual learning preferences of the pupils, so each will be different.

Gur, Raquel E., Gur, Ruben C., and Marshalek, Brachia, "Classroom Seating and Functional Brain Asymmetry," Journal of Educational Psychology 67:151-153, February, 1975.

This study examined the relationship between laterality and preference for sitting on the left or right side of a classroom. Laterality was determined by measuring the characteristic direction of eye-movement in face-to-face questioning. Subjects were seventy-four undergraduate students whose eye directionality had already been established. Seating preference was determined by the use of a questionnaire showing a diagram of a classroom. The subjects marked their seating preference and were then told to mark any special preferences they had based on the material being taught. Distinctions were made between "hard" (math, physics) and "soft" (art, music) topics. Results showed that left movers preferred to sit on the right side of the classroom more often than right movers. Right movers preferred to sit on the left more often than left movers. All subjects who expressed a different preference based on topic tended to move to the left for hard topics.

Vitale, Barbara Meister, Unicorns Are Real: A Right-Brained Approach to Learning, Jalmar Press, Rolling Hills Estates, Cal., 1982, 119 pp.

Vitale stated that research on lateralization had important implications for education, especially since schools traditionally use one teaching mode: left-brained. She noted that both parents and school personnel must recognize hemispheric differences and make allowances for them. Left-brained learners process information from the parts to the whole, while right-brained learners process holistically (from the whole to the parts). Vitale stated that both processing methods use high-level thinking skills. To decide a child's dominant hemisphere (the one used for most tasks), Vitale suggested a behavioral checklist of characteristics that right-brained children may exhibit. She also provided a series of informal tests to help teachers or parents identify a learner's dominant hemisphere. Research showed that since children learn within their own universe of experience, schools should adapt their methods to the needs of the child, not vice-versa. To facilitate this adaptation, Vitale provided numerous specific teaching techniques for right-brained learners.

Franklin, Robert B., compiler, The 4-MAT System in Elkhart: A Compendium of Classroom Units of Study Using the 4-MAT System, Elkhart Community School System, Elkhart, Inc., 1982, 251 pp. (Available through Elkhart Community Schools Educational Services Center.)

This collection of 4-MAT units provides detailed lesson plans in the areas of math, language arts, science, social studies, reading, music, personal growth, art, spelling, counseling, and vocational education. These units were created by teachers in the Elkhart system who attended a workshop with Bernice McCarthy (creator of the 4-MAT system) in 1982. The units cover grades K-12, including special programs, such as Title (now Chapter) I and the learning disabilities program. Many lessons can be adapted for other levels.

Bower, Gordon H., and Clark, Michal C., "Narrative Stories as Mediators for Serial Learning," Psychonomic Science 14:181-182, 1969.

Bower and Clark tested the ability of subjects to memorize serial lists of nouns through two methods. The control method used normal study and practice. The experimental (narrative) method used a technique for chaining the words into a meaningful story in the order in which they were to be recalled. Equal study time was given to both the control and narrative subjects. Immediate and long-term recall variables were studied. Results showed no difference for immediate recall-- both groups performed at > 99% median level. However, on the long-term recall task (after all twelve lists had been learned), the narrative group showed an average median recall of 93% compared to the control group's 13%. Bower and Clark postulated that the narrative group's success was due to thematic organization which helped subjects to generate meaning and discriminate between lists.

Carbo, Marie, "Be A Master Reading Teacher," Early Years 12:39-42, 47, February, 1982.

Carbo asserted that no one reading program would work with all pupils. Therefore, she provided suggestions for teaching reading through learning styles. Carbo suggested that teachers observe pupils' learning preferences or give the LSI, LSI-P (Dunn) or the Reading Style Inventory (Carbo, 1980), and then match pupil learning style to teaching styles. Carbo listed various ideas for matching teaching/learning styles, including use of language-experience, phonics, and individualized methods for teaching reading, suggestions for creating special study areas for pupils, provisions for multi-media and multi-sensory presentation, and organizational ideas for reading materials.

Carbo, Marie, "Teaching Reading the Way Children Learn to Read," Early Years 12:43-47, February, 1982.

In this article, Carbo provided numerous strategies for teaching reading to global learners. She noted her belief that most primary pupils learn best from global teaching methods, which use a whole-to-part approach. Carbo suggested that teachers make their own materials, and she gave detailed instructions for the creation of tape recorded books, book games, and writing activity cards. All of Carbo's suggestions contained a kinesthetic/tactile dimension since primary pupils often exhibit this sensory modality.

Roberts, Nancy M., "Imagery: A Second Look: Expanding its Use in the Classroom," Reading Improvement 20:22-27, Spring, 1983.

Roberts cited various research studies as evidence that imagery in the form of mnemonic devices is a powerful memory aid. Imagery can be used for both the processing and recalling of information. According to Roberts, imagery can also be used as an aid to problem solving, in the development of social skills, for identification of career possibilities, to enhance creativity in the arts, as an added dimension in math, as a link between concrete objects and symbols, in the areas of social studies, history and science, and finally as a tool for relaxation and reducing tension.

Wolfe, Denny T., Jr., and Reising, R.W., "Politics and English Teaching, Or (Can, Should, Will) We Teach the Whole Brain?" English Journal 67:33-35, May, 1978.

Wolfe and Reising based their suggestions for teaching to both brains on the premise that such a method will lead to verifiable evidence that pupils are learning, which becomes increasingly important in light of issues such as competency testing. Wolfe and Reising stated that right-brain learning enhances left-brain learning. They noted some basic right-brain strategies that can be used in English classes including word association games, photo essays, pantomime activities, and serial story-telling.

Goodwin, Nancy, "Dancing on the Stage in Your Head," English Journal 72:43-45, February, 1983.

Goodwin cited Julian Jaynes (1976) to state that human beings visualize on the stage in their heads. Goodwin experimented with this idea in her own classroom and found that helping pupils to visualize made lessons more real to them. Some activities that Goodwin found to be successful were: orally presenting descriptive words to create images in pupils' heads, then asking pupils to create images for others; using a series of image-rich resources to help pupils become part of whatever material is being studied; and role-playing important literary passages.

Wharton-Boyd, Linda F., "The Significance of Black American Children's Singing Games in an Educational Setting," Journal of Negro Education 52:46-56, Winter, 1983.

Wharton-Boyd stated that Black American children's singing games can be applied to education in the areas of curriculum, teaching strategies, character development, and development of self-expression. She described the structure and history of these singing games and listed some examples. She stated that singing games can be used to teach spelling (spelling to a rhythm with added body movements), vowel/consonant sounds and syllabication (through "scatting"), and vocabulary development (with games requiring the child to think of new words). Science, math, and social studies skills can also be reinforced through these games. Wharton-Boyd noted that due to the rule structures of many of the games, pupils can strengthen their group cooperation and performance skills. She warned that singing games should not be used to the exclusion of other teaching methods.

Burns, Marilyn, The I Hate Mathematics Book, Little, Brown, and Co., Boston, 1975, 127 pp.

Burns' book was written primarily for children but contains many useful ideas for teachers and parents. Burns' purpose was to create activities to make math more interesting and fun. Many of the activities would stimulate right-brain functioning, including numerous puzzles, geometry problems, and magic tricks. Adding a few of these activities to the math curriculum could help stamp out "humdrum."

Wheatley, Grayson H., "The Right Hemisphere's Role in Problem Solving," The Arithmetic Teacher 25:36-38, November, 1977.

Math may not seem to be a subject that lends itself to right-brained learning, but Wheatley asserted that the right brain can be indispensible in problem-solving. Wheatley cited evidence that children pass through three stages in problem-solving: 1) They form a plan for solving by "playing around with the problem." 2) They apply a chosen method (often a learned algorithm). 3) They reflect on the problem. The right brain would be involved in steps one and three. Wheatley noted that teachers often hinder pupils in problem-solving by teaching only methods (algorithms) instead of helping them to explore solution possibilities. He suggested that teachers include puzzles, open-ended tasks, multiple-solution problems, and laboratory/discovery approaches in their teaching.

Birdd, Donald L., "Trimming the Creativity Tree," The Science Teacher 49:26-27, December, 1982.

Birdd suggested an interesting technique for engaging the whole brain in the study of science. He had each of his pupils create a model illustrating a concept taught during the grading period. In addition to the model, each pupil was required to give a five-minute oral presentation using information which was not discussed in class. Each pupil had to show how her/his project related to everyday life. Birdd noted that some pupils needed more teacher-encouragement than others to complete their assignments.

Edwards, Betty, Drawing on the Right Side of the Brain, J.P. Tarcher, Inc., Los Angeles, 1979, 207 pp.

Edwards created a method for improving drawing skill by using information from research dealing with hemispheric specialization. She described the research findings as a part of her method, explaining that knowing how the brain functions helps to facilitate the mode shifts needed for drawing. Edwards based her method on the premise that using the intuitive right brain would result in a new way of seeing. She devised a sequential series of exercises designed to help a person to gain access to the special skills of the right hemisphere. One of these exercises entails copying a line drawing upside-down. Edwards concluded with a brief explanation of ways to adapt her method for children.

Joyce, Bruce, and Weil, Marsha, Models of Teaching, Second Edition, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1980, 499 pp.

The authors presented twenty-three models for teaching, separated into four "families": information-processing, personal, social, and behavioral. Of these twenty-four, eleven are of special importance to elementary teachers wishing to create classrooms which allow for differences in learning style. These are: cognitive growth, the inquiry models, group investigation, advance organizers, concept attainment, the memory model, synectics, stress reduction, and role-playing. Joyce and Weil concluded their book with suggestions for choosing appropriate models, some hints for matching models to students, information concerning mastery learning and optimum learning conditions, and a "brainwashing model" which is meant as a warning against some of the more traditional classroom strategies. [Connections between these models and the research of various brain theorists will be made in the concluding pages of this paper.]

SUMMARY

Since the days of the first split-brain experiments, numerous studies have explored the neural connections between the hemispheres (e.g., Gazzaniga, 24), using a variety of methods (Springer and Deutsch, 16-30). In recent years many researchers have examined the brain in relation to educational implications. Some well-established findings emerged. One of them was that the brain exists in two parts, but those parts work best together (Bogen, 1973, 113-116). Language may be the major difference between the hemispheres (Springer and Deutsch, 59). (For other differences, see Appendix D.) The right brain's non-verbal abilities may make it important in judging the authenticity of verbal messages (Rice and Languis, 52). Mixed results were obtained from studies of handedness: it may (Wellman, 55) or may not (Springer and Deutsch, 21) conclusively predict hemispheric dominance. Similarly, creative style was found to relate positively to right-brain functioning, but creative ability showed no relationship to hemispheric dominance (Torrance, 36). Some sex differences in lateralization and brain function were found to exist (Reynolds, Kaltsounis, and Torrance, 759, and others) but the total significance of the findings may be small (Hyde, analyzing Maccoby and Jacklin's findings, 892, 894, 897). Researchers studying ear asymmetry and reading ability found only a weak differentiation between good and poor readers (Watson and Engle, 16).

One researcher questioned all research on hemispheric specialization on the grounds that the assessment instruments may be inadequate (Shook, 15). (He did not make clear what he meant by inadequate.) He also contended that culture, not heredity, was responsible for hemispheric

specialization (Shook, 11), an idea which received some corroboration from a later study by Shade (228). Most researchers agreed that some questions remain, and that these questions will only be answered by further study and cooperation between educators and neuroscientists.

Research studies by Epstein and MacLean took a different direction than the split-brain experiments. Epstein's brain growth periodization theory was based on findings that 35% of the brain's growth happens after the cessation of new cell production (Epstein, 343). He identified five stages during which the brain grows in "spurts." He claimed that, for 85% of the subjects tested, these stages occurred between the ages of 3-10 months and 2-4, 6-8, 10-12 (maybe 13) and 14-16 (maybe 17) years. These stages were found to correspond to the four intellectual development stages of Piaget and, more recently, to a fifth stage proposed by Arlin (Epstein, 344).

MacLean described his "triune brain" as three-part system made up of the r-complex which is responsible for routine and ritual ("primal") functions; the limbic system, which provides for emotions, procreation, and self-preservation; and the neocortex which controls rational behavior.

The great diversity in learning style theory should provide a more complete approach to education, according to Dunn (1981, 374), whose own theory formed the basis for many later studies. Dunn claimed that 21 elements, based around physical, emotional, sociological, environmental, and personal needs, could have an important effect on learning. Dunn used a self-report inventory to determine the factors that are important to each learner (Dunn, Jan., 1983, 25-26). Various studies using the

instrument have reported academic gains when learning preferences and teaching styles are matched (Dunn, Feb., 1983, 61).

The sensory modalities (included as part of the Dunn inventory) formed the basis of Barbe and Milone's theory. Studies using the Barbe/Swassing Modality Index (the assessment component of the theory) found that about 30% of elementary children learned best through the visual mode, 25% through the auditory, and 15% through the kinesthetic. The other 30% exhibited mixed modality strengths, which Barbe and Milone claimed gave them an advantage in school (Barbe and Milone, 45). This claim was supported by Dunn, who reported that gifted pupils tended to learn through a combination of modalities (Dunn, Feb., 1983, 53). It was found that modality strengths become more mixed as children get older (Barbe and Milone, 45).

The learning style theories of McCarthy and Gregorc were based on a similar construct and identified four distinct styles of processing information and perceiving reality (Gregorc and Ward, 22, and McCarthy, 37-43). McCarthy's "Type 1" learners possessed characteristics similar to Gregorc's "abstract random" learners, and the other styles converged as follows: "Type 2"/"abstract sequential", "Type 3"/"concrete sequential," and "Type 4"/"concrete random" (McCarthy 30, 35). McCarthy's "4-MAT" teaching model included a right/left/whole-brain component for each style, and it concurred with the growth and development stages of Epstein and Piaget (McCarthy, 59-65). Both Gregorc and McCarthy contended that teaching to all styles in each lesson would give pupils success in their own style and build their strengths in other styles (Gregorc and Ward, 25, and McCarthy, 53). Most other learning style researchers supported this contention.

Davidman questioned some tenets of learning style theory, including the idea that children's preferences should decide how a classroom is structured. He felt that pupils, as well as teachers, should adapt (Davidman, 642). Davidman and Gregorc both questioned the validity of self-report instruments (such as the Dunn LSI) on the grounds that pupils may intentionally conceal their true preference or report a preference for elements with which they are merely most familiar (Gregorc, 235). According to Kuchinskas (270), the real issue wasn't pupil learning styles anyway - she found that the teacher's cognitive style was more important than any other factor in shaping classrooms (and learning).

Various studies of sex differences related to lateralization presented evidence that girls showed greater verbal ability while boys did better on visual-spatial tasks (Keenan and Smith, 50, and others). In one study, boys were shown to exhibit right-hemispheric specialization for spatial tasks earlier (by age six) than girls (about age thirteen) (Witelson, 425). In a study considering the implications of sexual dimorphism in the corpus callosum, the female splenium was found to be larger than the male splenium (de Lacoste-Utamsing, Holloway, 1431). Because of the corpus callosum's function as the connection between the hemispheres, this dimorphism may be one reason why women tend to be less lateralized than men (de Lacoste-Utamsing and Holloway, 1432). Due to some inconsistencies in findings, possible sex bias in data, and other problems, most researchers suggested that schools avoid planning on the basis of sex differences in cognitive abilities.

Shade, Slaughter, Ramirez, Price-Williams, and Cureton all studied

the effects of cultural differences on cognitive style. Shade, Slaughter, and Cureton postulated the existence of an Afro-American cognitive style that was field-dependent (among boys, Slaughter, 197; for both sexes, Shade, 230); non-auditory (Cureton, 752); visual, holistic, intuitive, people-oriented, and adept at assessing non-verbal cues (Shade, 220). Ramirez and Price-Williams reported that Mexican-Americans exhibit a similar field-dependent style (Ramirez III and Price-Williams, 216). Shade, Ramirez and Price-Williams described the discrepancy between the school's cognitive style and that of Afro- (and Mexican-) Americans. This discrepancy was cited as a possible cause of school difficulties for these learners (Shade, 232-233; and Ramirez and Price-Williams, 218). There was a general consensus among these researchers that educators should be aware of and adapt to cultural differences in cognitive style. Hollins also suggested a need for the creation of a multi-cultural theory of learning (Hollins, 144-145).

CONCLUSIONS

Although some discrepancies in terms exist, most researchers point to the duality of the human brain. The brain growth stages of Epstein and MacLean's triune brain add another dimension to the body of knowledge about how the brain processes information. Further study could show ways in which a combined theory including all three organizational structures of the brain might provide a more solid foundation on which educators can build.

Learning style theory is so diversified that finding interrelationships between all of the points of view would be an almost-impossible task. However, certain elements could be gleaned from the various theories and combined to create a more personalized form of education, one that fits the needs of pupils, teachers, the school, and the society as a whole. Before major curriculum changes are instituted, further study is needed to determine which elements of learning style are most necessary in providing optimum learning environments. In the meantime, the classroom teacher could make some changes which could augment the learning environment by building on present strengths and trying some new ideas. Any strategies which are implemented should be carefully monitored; ideas that aren't working should be discarded.

As far as sex differences are concerned, too little is known for sure to make teaching to those differences a safe gamble. Similarly, cultural differences should be carefully considered before making any major adjustments in planning or curriculum. The days of "tracking" pupils by race or sex are not so far in the past that educators can

ignore their consequences.

In general, it appears that the best plan of action is a varied one, one which considers each pupil as an individual and each learning situation as one in which a variety of teaching methods and pupil responses will be used.

RECOMMENDATIONS

It is recommended that teachers:

1. Teach to all modalities (Barbe and Milone, 47) and to each style, as much as possible (McCarthy, 90, and others).
2. Engage the emotion of the right brain (Levy, 68) or the limbic system (MacLean, 330-332) to motivate pupils. (See also McCarthy, 42).
3. Provide ways for pupils to become actively involved in learning (Wittrock, 13, and others).
4. Spend some time involved in activities which expand pupils' present knowledge (9-year-olds) and present higher-level thinking skills for those pupils who are ready (10-13-year-olds). (See Epstein, 364-5, Toepfer, 5, 8-9 and Cramer, 18-20, for details).
5. Give pupils a wide variety of ways to respond to lessons -- oral or written words; pictures, diagrams or models; drama or role-playing. (See Eisner, 56-68 for some specific ideas).
6. Be aware of the non-verbal component of verbal messages. Try to keep the messages matched (Rice and Languis, 52-53).
7. Use music, dance, art, and video media in all subjects to stimulate the right brain.
8. Don't try to alter a pupil's handwriting position. Teach correct methods to use for each position (Wellman, 51).
9. Allow more pupil response time (Brandwein and Ornstein, 58) and help pupils to visualize before answering (Roberts, 27, and others).
10. Consider redesigning the classroom to allow for variation in pupil

preference for seating (Gur, Gur, and Marshalek, 153) and environmental elements (Dunn, Jan. 1983, 25-27+).

11. Allow for individual pupil preference for emotional factors. (See diagram p. 224 in Price article.)

12. Use "color shock" technique (Vitale, 68).

13. Provide examples before assigning activities to aid global, right-brained learners (Vitale, 75).

14. Give practice exercises at the chalkboard or use lap-boards (Vitale, 79).

15. Try playing music (softly) during learning activities and work times (Vitale, 102).

16. Have students use narrative stories as a memory aid (Bower and Clark, 181-182).

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APPENDIX A

SPECIFIC TEACHING STRATEGIES

Note: Some activities may need to be revised for use with elementary pupils.

READING	R	FD	V	A	K	AA	*
1. Make tape recorded books, book games, and writing activity cards for student use.				X			
2. Use the language -experience approach (Example: Franklin, 185).	X						X
3. Teach pupils to use visualization as an aid in reading comprehension (Goodwin, 45, and others).	X		X				X
4. Use 4-MAT lessons: "Outlining Lions or Getting the 'Mane' Idea" (Franklin, 61-66). "Noting Details" (Franklin, 124-127). "Reading" (McCarthy, 133-136). "Reading Comprehension" (McCarthy, 175-178).							X
5. Use "whole word" approaches (Vitale, 41,76).	X						
6. Use "word pattern" approaches (Vitale, 42, 72).	X						
7. Include haptic activities (Vitale, 30, 40, 43).	X				X		
8. Use choral reading to improve fluency (Vitale, 104 and Cureton, 743-754).	X			X		X	
9. Add body movement activities to syllabication and other reading lessons (Vitale, 46, and Cureton, 753).	X				X	X	X
10. Use "magasine tracking" (Vitale, 89).	X	X			X		

Key to symbols: R-for right-brained learners, FD-for field-dependent learners, V-for visual learners, A-for auditory learners, K-for kinesthetic learners, AA-for learners who exhibit an Afro-American cognitive style, *-for various modes/styles- to reach a wide variety of learners.

LANGUAGE ARTS	R	FD	V	A	K	AA	*
1. Use haptic activities for spelling (Vitale, 29, 84, 94, 95) and English (Vitale, 71).	X				X	X	
2. Teach pupils to visualize as an aid to memory (Vitale, 101, and Roberts, 22) and as a preface to writing (Goodwin, 45).	X		X				X
3. Have pupils role-play and pantomime stories (Wolfe and Reising, 31).					X	X	X
4. For creative writing, begin with a series of image-rich resources (Goodwin, 44-45).							X
5. Use 4-MAT lessons: "Punctuation" (McCarthy, 137-140). "Casey at the Bat" (McCarthy, 95-121). "Descriptive Writing" (Franklin, 89-91). "Making Words Come ALIVE!" (Franklin, 43-48). "Recognizing and Using Verbs" (Franklin, 240-246).							X
6. Use singing games to teach spelling and develop vocabulary (Wharton-Boyd,46-56).	X			X		X	X
MATH							
1. Use varied activities, including puzzles and magic tricks (Burns, 1-127).	X				X	X	X
2. Teach and accept right-brain techniques for problem-solving (Wheatley, 37-38, and Vitale, 45).	X						X
3. Help children find patterns in column-addition problems (Vitale, 53).	X	X	X				
4. Suggest alternate algorithms (Vitale, 54, 55).	X						X
5. Use haptic methods to practice facts (Vitale, 30, 100).	X				X		
6. Suggest special organizational plans for working problems and completing assignments (Vitale, 63, 64, 66, 74).	X						X

	R	FD	V	A	K	AA	*
7. Use 4-MAT lessons: "Place Value Concept" (McCarthy, 141-146). "Fractions" (McCarthy 157-162 and 163-168). "Introduction of Division" (Franklin, 39-42). "Making Bar Graphs" (Franklin, 71-74). "Subtraction, Borrowing/Regrouping (Franklin, 222-232).							X
SCIENCE							
1. Have pupils create a model illustrating a learned concept (Birdd, 26-27).	X						X
2. Use 4-MAT lessons: "Discovering the Planets in Our Solar System" (Franklin, 49-54). "Insects" (McCarthy, 153-156).							X
SOCIAL STUDIES							
1. Use 4-MAT lessons "Pioneers in Indiana" (Franklin, 55-58). "The Rise of Modern America" (McCarthy, 193-196. Basic Strategies can be adapted for elementary).							X
2. Use role-playing and visualization (Roberts, 22-25, 27).	X		X		X		

APPENDIX B

MORE SOURCES FOR IDEAS

1. Books and journal articles mentioned in Appendix A.

2. For art - Drawing on the Right Side of the Brain, by Betty Edwards.

3. For science (based on Epstein's stages) - Towards a Science of Science Teaching by Michael Shayer and Philip Adery.

4. For right-brain development - Educating the Forgotten Half by James L. Lee and Charles J. Pulvino.

5. For more 4-MAT lessons, look for McCarthy's new book which is available from EXCEL, Inc. (See McCarthy reference in bibliography for address.)

[Please note: Complete bibliographical information is included for the Shayer/Adey and Lee/Pulvino books, even though they were received too late to be included in the body of this paper.]

APPENDIX C

TEACHING MODELS	MODES OR STYLES WITH WHICH THE MODEL SHOULD BE PARTICULARLY EFFECTIVE	RELATED TO WHICH THEORIES
Inquiry (3 forms)	Field-Dependent	4-MAT (McCarthy)
Cognitive Growth	All	Brain-Growth Periodization (Epstein)
Group Investigation	Peer or Adult-Oriented, Independent, or Varied	Split-Brain, 4-MAT, Dunn
Advance Organizers	Right- and -left Brain, Field-Dependent, Visual	Split Brain, 4-MAT. Modality (Barbe and Milone)
Concept Attainment	Right-Brain, Field Dependent	Split-Brain
Memory Model	Right-Brain	Split-Brain
Synectics	Right-Brain, Kinesthetic	Split-Brain, 4-MAT, Modality
Stress Reduction	Right-Brain	Split-Brain
Role Playing	Right-Brain, Kinesthetic	Split-Brain, Modality

Source: Models of Teaching (Joyce and Weil)

APPENDIX D

LEFT, RIGHT, INTEGRATED BRAIN DOMINANCE CHARACTERISTICS

Left	*Right*	*Integrated*
• Intellectual	• Intuitive	Equally facile at both
• Remembers names	• Remembers faces	Equally facile at both
• Responds to verbal instructions and explanations	• Responds to demonstrated, illustrated or symbolic instructions	Equally facile at both
• Experiments systematically and with control	• Experiments randomly and with less restraint	Equally facile at both
• Prefers solving problems by breaking them down into parts, then approaching the problem sequentially, using logic	• Prefers solving problems by looking at the whole, the configurations, then approaching the problem through patterns, using hunches	Equally facile at both
• Makes objective judgments, extrinsic to person, looks at otherness	• Makes subjective judgment, intrinsic to person, looks at sameness	Equally facile at both
• Planned and structured	• Fluid and spontaneous	Equally facile at both
• Prefers established, certain information	• Prefers elusive, uncertain information	Equally facile at both
• Analytic reader	• Synthesizing reader	Equally facile at both
• Primary reliance on language in thinking and remembering	• Primary reliance on images in thinking and remembering	Equally facile at both
• Prefers talking and writing	• Prefers drawing and manipulating objects	Equally facile at both
• Prefers multiple choice tests	• Prefers open-ended questions	Equally facile at both
• Prefers work and/or studies carefully planned	• Prefers work and/or studies open-ended	Equally facile at both
• Prefers hierarchical (ranked) authority structures	• Prefers collegial (participative) authority structures	Equally facile at both
• Controls feelings	• More free with feelings	Equally facile at both
• Responds best to auditory, visual stimuli	• Responds best to kinetic stimuli (movement, action)	Equally facile at both
• Not facile in interpreting body language	• Good at interpreting body language	Equally facile at both
• Responsive to structure of environment	• Essentially self acting	Equally facile at both
• Rarely uses metaphors and analogies	• Frequently uses metaphors and analogies	Equally facile at both
• Favors logical problem solving	• Favors intuitive problem solving	Equally facile at both
• Prefers single variable research	• Prefers multi-variable research	Equally facile at both

Adapted from *Your Style of Learning and Thinking, Forms B and C* by E. Paul Torrance[9], University of Georgia, Athens, GA. 30602

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